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Technical Assessment Document

Further Study Measure 10:

Organic Liquid Storage Tanks

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

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1.0 Executive Summary

1.1 Introduction and Scope

The Bay Area 2001 Ozone Attainment Plan includes two action items related to storage tanks: Control Measure SS-12 and Further Study Measure FS-10. Control Measure SS-12 focused on monitoring requirements and was implemented through an amendment of Regulation 8, Rule 5 ("Storage of Organic Liquids") in November, 2002. Further Study Measure FS-10, the subject of this report, focuses on enhanced control requirements for tanks.

Two meetings of a FS-10 workgroup were held during the preparation of this report. The workgroup included District staff, representatives from industry, including all Bay Area refineries, and a representative designated by a number of Bay Area environmental groups.

FS-10 includes the following study items:

1) The study will quantify the emission reduction available by requiring controls on tanks that store liquids with a vapor pressure of 0.5 psia or less, and that are not currently subject to Regulation 8, Rule 5 in accordance with the exemption in Regulation 8-5-117. This item will include consideration of available test methods for measuring liquid vapor pressures below 0.5 psia.

2) The study will quantify the emission reduction available by requiring conversion of external floating roof tanks (EFRTs) to internal floating roof tanks (IFRTs).

3) The study will quantify the emission reduction available by imposing more stringent tank cleaning standards than are currently required by Regulation 8-5-328.

4) The study will examine the issue of whether the use of vapor recovery provides significant benefits over the use of internal or external floating roofs, based on Bay Area data and experience.

In addition to these items, this report studies another issue related to tank emissions:

5) The study will examine the issue of whether a maintenance program provision should be added to Regulation 8, Rule 5 to encourage more frequent self-inspection of tanks than is currently required by the rule.

1.2 Summary of Conclusions and Recommendations

1) Lowering vapor pressure applicability criterion of Regulation 8, Rule 5. Based on data from the District database, 154 fixed roof tanks would be required to be replaced with floating roof tanks, retrofitted with floating roofs or provided with an emission control system if the current vapor pressure applicability criterion in Regulation 8, Rule 5 were lowered from 0.5 psia to 0.1 psia. The potential emission reduction is approximately between 100 ton/yr and 160 ton/yr, with a cost effectiveness between $20,500 per ton and $34,000 per ton.

Rule 1178 ("Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities") at the South Coast AQMD recently implemented requirements for tanks in this pressure range. Based on the implementation of this rule, it appears that adequate surrogate analytic methods are available to measure low vapor pressure materials, with the notable exception of crude oils. This methodology would allow enforcement of standards for materials with vapor pressures as low as 0.1 psia.

Because the cost of implementation for this measure is quite high, other control measures should take precedence in rulemaking.

2) Retrofitting EFRTs with domes. A lack of readily available data on specific rim seal designs and deck fitting designs and counts at tanks in the District makes it difficult to quantify the potential emission reduction from this measure. However, U.S. EPA's emission correlations for floating roof tanks indicate that retrofitting EFRT's with domes can significantly reduce overall emissions from these tanks. The 310 EFRTs currently in service are estimated to produce over 800 tons per year of organic emissions. Dome retrofits could reduce this emission level by 50% or more, as discussed in Section 3.2.2. Because of the significant potential emission reductions, further research should be undertaken to more precisely establish the available emission reduction and cost effectiveness of this measure.

3) Imposing more stringent tank cleaning standards. Although the emission reductions available through this control measure do not appear to be large, the District could undertake rulemaking to require a minimum abatement efficiency of 95% by weight for control of degassing emissions, and improve the monitoring of degassing abatement by requiring real-time monitoring of degassing operations, instead of the currently required annual source test. Rulemaking could also be undertaken to impose sludge handling requirements that would minimize fugitive emissions and odors from tank sludge.

4) Benefits of vapor recovery compared to floating roofs. Where a facility can make use of recovered tank vapors for fuel, as at several refineries, vapor recovery abatement of fixed roof tanks offers the highest possible abatement of tank emissions, approaching 100%. For other vapor recovery technologies, it is difficult to continuously provide the same level of abatement as a floating roof, which is typically over 90%. Floating roof tanks are almost 5 times as common as fixed roof tanks abated by vapor recovery in the Bay Area. Because of the reliability of floating roofs, which are a passive abatement technology, it is not clear that vapor recovery could offer a greater overall emission reduction, considering the greater likelihood of breakdowns with a vapor recovery system. Also, vapor recovery systems have a large variability in cost from facility to facility, depending on the existing facility infrastructure. This variability makes cost effectiveness calculations difficult and suggests that implementation costs would vary widely for different facilities. Also, floating roof tanks have a large range of emission levels, depending on tank size, material throughput and material vapor pressure. Therefore, rulemaking could be undertaken to determine which classes of floating roof tanks, if any, should be prohibited in favor of continuous vapor recovery with abated fixed roof tanks. Rulemaking could also determine whether non-continuous vapor recovery, as during the initial filling phase of an empty floating roof tank, should be required.

5) Maintenance program provision. The District should undertake rulemaking to amend Regulation 8, Rule 5 to include a maintenance program provision. This provision would encourage more frequent inspections of floating roof tanks by providing a limited amount of time to repair minor non-compliant conditions discovered by the tank operator, thereby reducing emissions.

2.0 Background

2.1 Further Study FS-10

The Bay Area 2001 Ozone Attainment Plan (Reference 1) is the strategy for the San Francisco air basin to achieve compliance with the 1-hour National Ozone Standard. Ozone is formed in the atmosphere by complex photochemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NOx). Because the storage of organic liquids results in emissions of VOCs, the Plan includes two action items related to storage tanks: Control Measure SS-12 and Further Study Measure FS-10. Control Measure SS-12 focused on monitoring requirements and was implemented through an amendment of Regulation 8, Rule 5 ("Storage of Organic Liquids") in November, 2002 (Reference 2). Further Study Measure FS-10, the subject of this report, will focus on enhanced control requirements for tanks subject to Regulation 8, Rule 5.

The scope of FS-10 includes the following four items, as described on Page 142 of the Plan:

1) The study will quantify the emission reduction available by requiring controls on tanks that store liquids with a vapor pressure of 0.5 psia or less, and that are not currently subject to Regulation 8, Rule 5 in accordance with the exemption in Regulation 8-5-117. This item will include consideration of available test methods for measuring liquid vapor pressures below 0.5 psia.

2) The study will quantify the emission reduction available by requiring conversion of external floating roof tanks (EFRTs) to internal floating roof tanks (IFRTs).

3) The study will quantify the emission reduction available by imposing more stringent tank cleaning standards than are currently required by Regulation 8-5-328.

4) The study will examine the issue of whether the use of vapor recovery provides significant benefits over the use of internal or external floating roofs, based on Bay Area data and experience.

Gasoline storage tanks that are regulated under Regulation 8, Rule 7 ("Gasoline Dispensing Facilities)" are not considered in this report. Diesel fuel tanks at retail service stations, although unregulated by Regulation 8, Rule 7, are also not considered in this report.

2.2 Other Study Items

5) Also examined in this report is the possible addition to Regulation 8, Rule 5 of a maintenance program provision that would encourage more frequent inspections of floating roof tanks by providing a limited amount of time to repair minor non-compliant conditions discovered by the tank operator. Regulation 8, Rule 5 currently does not include such a provision, and all non-compliant conditions, including minor conditions discovered and promptly corrected by the tank operator, are subject to enforcement action. A similar provision, allowing up to 7 days for repair of non-compliant leaks discovered by the operator, is included in Regulation 8, Rule 18 ("Equipment Leaks").

2.3 Organic Liquid Storage Tanks in the Bay Area

The District database currently includes 3,521 tank sources (See Section 4.1), both permitted and exempt. This total includes IFRTs, EFRTs, fixed roof tanks and pressure tanks, but excludes fuel tanks at retail service stations. This total also includes tanks that primarily hold water or primarily inorganic materials, although some organics may be present. In general, fixed roof tanks are used to hold low vapor pressure materials such as lube oils or distillate oils, while floating roof tanks are used to hold crude oils and higher vapor pressure refined products such as gasoline and naphtha. Pressure tanks are used for the highest vapor pressure liquids and pressurized gases.

Pressure Tanks	152 (at 28 facilities)		
Floating Roof Tanks	495 (at 31 facilities)	185 IFRTs	310 EFRTs
Fixed Roof Tanks	2,874 (at 309 facilities)		
Total Tank Sources	3,521 (at 310 facilities)		

The 3,521 tank sources are located at 310 facilities, and about 50% of these tanks (1,771) are classified as exempt from permits. However, only 48 facilities have 10 or more tanks, and these 48 facilities account for about 77% of the total number of tanks. Only 31 facilities have one or more floating roof tank.

2.4 Emission Inventory

The District estimates emissions from permitted tanks, and from tanks that are exempt from permits but that are included in the District database. All exempt tanks in the District are not included in the database and District regulations do not require that they be included. The District has operated under various policies with respect to exempt sources. During some periods, exempt sources that were identified in permit applications were added to the District database. During other periods, these sources were not added to the database. Current District policy is to add exempt sources to the database when they are identified in permit applications.

Each facility with active sources, whether permitted or exempt, has an emission inventory completed once each year as part of the permit renewal process. This process begins with a request for information regarding sources at a particular facility. For tanks, this information includes the types of material stored and the throughput of each material over a recent 12-month period. Generally, information for a specific tank is requested either every year or every fourth year, depending on the previously calculated level of toxic emissions and total organic emissions. In other words, an information request for a particular facility does not necessarily include every source every year. For tanks with high toxic emissions or high overall emissions, the District does request data each year. The District database performs an annual automated calculation of emissions at all sources, including tanks, using the most recent throughput and material type information.

Emissions from tanks are calculated using the correlations in U.S. EPA's AP-42 document, in the form that they appeared in Supplement 12 to the 3rd edition in 1981. The correlations were incorporated into the District database in 1981 and have not been revised. Since 1981, the correlations in AP-42 have been amended to include deck fitting losses for floating roof tanks, but this refinement has not been made in the District database. Deck fittings are penetrations through the roof of a floating roof tank. Deck fitting loss correlations were introduced in AP-42 in the Update Package for the 3rd edition for IFRTs in 1985 and in Supplement E of the 4th edition for EFRTs in 1992. In general, the inclusion of deck fitting losses significantly increases the emissions calculated by the AP-42 correlations. The study that led to the development of deck fitting loss correlations concluded that:

> *"… certain roof fittings have a high evaporative loss potential, and the total evaporative loss contribution of all of the roof fittings typically found on an EFRT is not negligible in comparison to the rim seal loss. In fact, with the current widespread use of secondary seals, the roof fitting loss can sometimes exceed the rim seal loss."* (Reference 3)

Thus, calculated emissions for floating roof tanks would be higher if the deck fitting losses were incorporated into the database. [Note: Although deck fitting correlations are not included in the District database, Regulation 8, Rule 5 does include design and inspection requirements for roof deck fittings.]

Another factor in tank emission calculations is the rim seal loss on floating roof tanks. Rim seal loss is the emission of organic vapors at the gap between the floating roof and the inner tank wall. This gap is partially closed by some type of rim seal attached to the floating roof. Tightening the tolerance between the rim seal and the tank wall may reduce rim seal losses. The AP-42 correlations assume "average-fitting seals" on all tanks, while an increasing number of tanks in the District are required to have tight-fitting seals, or "zero-gap" seals as they are sometimes called. These seals are actually allowed a gap up to 0.06 inch (Regulation 8-5-322.5). Thus, calculated emissions for many floating roof tanks would be reduced if the appropriate seal factor were incorporated into the database for zero-gap tanks. It should be noted that average-fitting seal factors are the only option offered in the AP-42 correlations, although the background documents for AP-42 provide alternative factors.

The AP-42 correlations, and an associated program that incorporates these correlations (TANKS), are the generally accepted guidelines for calculation of tank emissions. It is possible to measure tank emissions using technologies such as DIAL (Differential Absorption LIDAR). DIAL uses laser beams, directed across a vertical plane downwind of a source of emissions, coupled with optical detectors, to detect, identify and quantify emissions of specific compounds from a source. Unlike the AP-42 correlations, direct-measurement techniques like DIAL do not model tank operations, and their results are valid only for the particular tank condition during which they are used. Also, direct-measurement techniques may not be able to measure emissions on a source-specific basis, since sources may be located in such close proximity that only a measurement of combined emissions is possible. Finally, the cost of direct-measurement of emissions for even a small fraction of the installed tank base on an annual basis would be prohibitive. Thus, while direct-measurement techniques like DIAL have a number of potential applications, including validation of emission calculation methods, only a calculation method is practical for the purpose of maintaining an emission inventory system.

The District intends to incorporate deck-fitting losses into the next version of the emission inventory. This version will be implemented in conjunction with the next general upgrade of the District's database system.

2.5 Regulation 8, Rule 5

Regulation 8, Rule 5 ("Organic Liquid Storage Tanks") regulates organic liquid storage tanks in the District, except for gasoline tanks at retail service stations, which are regulated by Regulation 8, Rule 7 ("Gasoline Dispensing Facilities"). Regulation 8, Rule 5 was first adopted in 1978 and has undergone several major revisions. The rule was last revised in November 2002, and this version has been adopted into the State Implementation Plan (SIP). Regulation 8, Rule 5 includes design, operating, monitoring and recordkeeping requirements for tanks, tank seals on floating roof tanks and tank fittings. The basic design requirements for this rule are included in Section 8-5-301:

Tank Capacity	True Vapor Pressure of Tank Organic Contents		
	>0.5 to ≤1.5 psia	>1.5 to <11 psia	≥ 11 psia
≥1.0 m^3 to ≤37.5 m^3 (≥264 gallons to ≤9,906 gallons), aboveground only	Submerged fill pipe, internal floating roof, external floating roof, or approved emission control system	Pressure vacuum valve, internal floating roof, external floating roof, or approved emission control system	Pressure tank or approved emission control system
>37.5 m^3 to <75 m^3 (>9,906 gallons to <19,803 gallons), aboveground only	Submerged fill pipe, internal floating roof, external floating roof, or approved emission control system	Pressure vacuum valve, internal floating roof, external floating roof, or approved emission control system	Pressure tank or approved emission control system
≥75 m^3 to <150 m^3 (≥19,803 gallons to <39,626 gallons)	Submerged fill pipe, internal floating roof, external floating roof, or approved emission control system	Internal floating roof, external floating roof, or approved emission control system	Pressure tank or approved emission control system
≥150 m^3 (≥39,626 gallons)	Internal floating roof, external floating roof, or approved emission control system	Internal floating roof, external floating roof, or approved emission control system	Pressure tank or approved emission control system

Regulation 8, Rule 5 includes two broad exemptions: tanks smaller than 264 gallons (Regulation 8-5-110.1), and tanks storing liquids with a true vapor pressure less than or equal to 0.5 psia (Regulation 8-5-117). Because many of the tanks that are exempt from Regulation 8, Rule 5 in accordance with these sections are also exempt from permit requirements, it is unclear how many of these tanks are in the District, since sources that are exempt from permit requirements are not necessarily included in the District database. However, the District database includes 1,771 tank sources (See Section 4.1) that are exempt from permit requirements, including 236 tanks with a capacity of one million gallons or more.

2.6 Federal Regulations

In addition to Regulation 8, Rule 5, organic liquid storage tanks may be subject to the New Source Performance Standards (NSPS) in 40 CFR Part 60. Depending on their size and date of construction or modification, tanks may be subject to Subpart K, Ka or Kb of Part 60. The requirements for these standards are summarized below:

40 CFR Part 60, Subpart	effective dates	applicability criteria	design requirements

K	1) 3/8/74-5/19/78 2) 6/11/73-5/19/78	1) greater than 40,000 gallon but not greater than 65,000 gallon capacity 2) greater than 65,000 gallon capacity	floating roof, vapor recovery, or equivalent for liquids with a vapor pressure of 1.5 psia or more and no more than 11.1 psia; vapor recovery or equivalent for liquids with a vapor pressure greater than 11.1 psia
Ka	5/18/78-7/23/84	greater than 40,000 gallon capacity	EFRT with seals as specified OR fixed roof with an internal floating roof OR vapor recovery for liquids with a vapor pressure of 1.5 psia or more; vapor recovery with an abatement efficiency of at least 95% by weight for liquids with a vapor pressure greater than 11.1 psia
Kb	after 7/23/84	greater than or equal to 19,813 gallon capacity and greater than 4 psia vapor pressure greater than 39,890 gallon capacity and greater than 0.75 psia vapor pressure	EFRT with seals as specified OR fixed roof with an internal floating roof with seals as specified OR a closed vent system with no leaks of 500 ppm or more; vapor recovery with an abatement efficiency of at least 95% by weight for liquids with a vapor pressure greater than 11.1 psia

2.6.1 NSPS Subpart K (40 CFR 60.110)

Subpart K addresses only tanks with a capacity greater than 40,000 gallons. For those tanks that are addressed, the basic design requirements are the same as in Regulation 8, Rule 5. However, this standard does not impose seal gap standards or address deck fittings.

2.6.2 NSPS Subpart Ka (40 CFR 60.110a)

Subpart Ka addresses only tanks with a capacity greater than 40,000 gallons. For those tanks that are addressed, the basic design requirements are similar to those in Regulation 8, Rule 5. Subpart Ka includes seal gap criteria for both the primary and secondary seals on EFRTs, and design requirements for deck fittings on EFRTs and IFRTs. For EFRTs, seal gap criteria are expressed as limits on the maximum gap at any point, and limits on the cumulative area of the gaps per unit of tank diameter. Seal gap limits in Regulation 8, Rule 5 are expressed as limits on the maximum gap at any point, and limits on the total length of seal with gaps exceeding a specified limit. Thus, only the maximum gap standards are directly comparable. Subpart Ka generally allows a smaller maximum gap for primary seals (1/2 inch) than Regulation 8, Rule 5 (1/2 inch for resilient toroid seals, 1-1/2 inch for mechanical seals on welded tanks and 2-1/2 inches for mechanical seals on riveted tanks). However, Subpart Ka allows a much larger maximum secondary seal gap (1/2 inch) than Regulation 8, Rule 5 (0.06 inch) does for new tanks (welded EFRTs with seals installed after September 4, 1985 or welded IFRTs with seals installed after February 1, 1993). The 0.06 inch standard is commonly referred to as a “zero-gap” seal standard. For older tanks, Regulation 8, Rule 5 has the same secondary seal gap standard (1/2 inch) as Subpart Ka. Regulation 8, Rule 5 has no secondary seal gap standard for riveted tanks.

2.6.3 NSPS Subpart Kb (40 CFR 60.110b)

Subpart Kb addresses only tanks with a capacity greater than 10,566 gallons. For those tanks that are addressed, the basic design requirements are similar to those in Regulation 8, Rule 5. Subpart Kb includes seal gap criteria for both the primary and secondary seals on EFRTs, and design requirements for deck fittings on EFRTs and IFRTs. For EFRTs, seal gap criteria are expressed as limits on the maximum gap at any point, and limits on the cumulative area of the gaps per unit of tank diameter. Like Subpart Ka, only the maximum gap standards are directly comparable with the standards in Regulation 8, Rule 5. Subpart Kb allows a maximum gap of 1-1/2 inches on primary seals, and up to 1/2 inch on secondary seals.

2.6.4 Summary of Federal Regulations

The requirements of these federal regulations are similar to those in Regulation 8, Rule 5. The federal regulations do not regulate liquids with a vapor pressure less than 0.5 psia and do not address tank cleaning. Like Regulation 8, Rule 5, these regulations treat IFRTs and EFRTs as equivalent control measures, and require vapor recovery only for high vapor pressure (greater than 11.1 psia) tanks. Regulation 8, Rule 5 and the federal regulations both require a minimum 95% abatement efficiency for vapor recovery systems. Thus, the federal regulations do not provide guidance regarding the four study items in FS-10.

2.7 Other California Air Districts

The following regulations from the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD), the Ventura County Air Pollution Control District (VCAPCD), the Santa Barbara County Air Pollution Control District (SBCAPCD) and the South Coast Air Quality Management District (SCAQMD) have been reviewed:

- SJVUAPCD Rule 4623, Storage of Organic Liquids, 12/20/01
- VCAPCD Rule 71-2, Storage of Reactive Organic Compound Liquids, 9/26/89
- VCAPCD Rule 74-26, Crude Oil Storage Tank Degassing Operations, 11/8/94
- VCAPCD Rule 74-27, Gasoline and ROC Liquid Storage Tank Degassing Operations, 11/8/94
- SBCAPCD Rule 326, Storage of Reactive Organic Compound Liquids, 1/18/01

- SBCAPCD Rule 343, Petroleum Storage Tank Degassing, 12/14/93
- SCAQMD Rule 463, Storage of Organic Liquids, 3/11/99
- SCAQMD Rule 1149, Storage Tank Degassing, 7/14/95
- SCAQMD Rule 1178, Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities, 12/21/01

These California agencies were selected because they have substantial numbers of organic liquid storage tanks and because, like the District, they are not in attainment with the California ambient ozone standard. Two of these regulations, SJVUAPCD Rule 4623 and SCAQMD Rule 1178, are of particular interest because they were recently adopted or amended.

2.7.1 SJVUAPCD Rule 4623

The 2001 amendment of SJVUAPCD Rule 4623 implemented Best Available Retrofit Control Technology (BARCT) and "all feasible emission control measures" (as required for non-attainment areas by the California Clean Air Act) to organic liquid storage tanks. The amendment lowered the applicability criteria for true vapor pressure from 1.5 psia to 0.5 psia, and implemented periodic vapor pressure testing of uncontrolled fixed roof tanks. The basic control requirements (listed in Table 1 of the rule) are equivalent to the requirements of Regulation 8-5-301. The rule also requires abatement of sludge from tanks storing liquids with a vapor pressure greater than or equal to 1.5 psia, and limits steam cleaning of tank interiors.

2.7.2 VCAPCD Rule 71-2

This rule includes an applicability criterion for true vapor pressure of 0.5 psia. The basic control requirements (listed in Section B of the rule) are equivalent to the requirements of Regulation 8-5-301.

2.7.3 VCAPCD Rule 74-26 and 74-27

These rules regulate degassing operations for organic liquids. The basic control requirements are equivalent to the requirements of Regulation 8-5-328. However, both of these regulations require real-time monitoring of the organic concentration of the vapor leaving the tank, and of the vapor leaving the control device, thus allowing positive verification of compliance with the 10,000 ppm criteria for a properly degassed tank, and compliance with the 95% abatement requirement. Regulation 8-5-328 relies on an annual source test of degassing control equipment for compliance verification.

2.7.4 SBCAPCD Rule 326

This rule includes an applicability criterion for true vapor pressure of 0.5 psia. The basic control requirements are equivalent to the requirements of Regulation 8-5-301.

2.7.5 SBCAPCD Rule 343

This rule regulates degassing operations for organic liquids. The basic control requirements are similar to the requirements of Regulation 8-5-328, except that the applicability criterion is a vapor pressure of 2.6 psia, rather than the 0.5 psia of Regulation 8-5-328, and the abatement efficiency requirement in this rule is 90%, while Regulation 8-5-328 requires 95%.

2.7.6 SCAQMD Rule 463

This rule includes an applicability criterion for true vapor pressure of 0.5 psia. The basic control requirements (listed in Section B of the rule) are equivalent to the requirements of Regulation 8-5-301. However, Rule 463 includes a limit on the organic concentration in the vapor space above the roof of internal floating roof tanks, which Regulation 8, Rule 5 does not.

2.7.7 SCAQMD Rule 1149

This rule regulates degassing operations for organic liquids. The basic control requirements are similar to the requirements of Regulation 8-5-328, except that the abatement efficiency requirement in this rule is 90%, while Regulation 8-5-328 requires 95%.

2.7.8 SCAQMD Rule 1178

This rule implements emission reductions at tanks related to petroleum refining and distribution facilities that have facility-wide VOC emissions in excess of 20 ton/yr in the year 2000 or later. The rule applies to tanks with a capacity of 19,815 gallons or more that store organic liquids with a vapor pressure of 0.1 psia or more. The requirements for tanks with vapor pressures between 0.1 psia and 3 psia are equivalent to the basic control requirements in Section 8-5-301 of Regulation 8, Rule 5. In addition, external floating roof tanks which store organic liquids with a vapor pressure of 3 psia or more are required to provide these tanks with domes in accordance with a schedule that extends through January 1, 2008.

2.7.9 Summary of California Air District Regulations

The regulations reviewed show that the District meets or exceeds the standards set by other California air districts, with the following exceptions:

- SJVUAPCD Rule 4623 requires abatement of sludge from tanks storing liquids with a vapor pressure greater than or equal to 1.5 psia, and limits steam cleaning of tank interiors.

- VCAPCD Rules 74-26 and 74-27 require real-time monitoring of degassing operations, while District Regulation 8-5-328 relies on an annual source test of degassing control equipment, and also require a minimum abatement efficiency for degassing control devices of 95%, while Regulation 8-5-328 requires only 90%.

• SCAQMD Rule 1178 lowers the applicability criteria for tanks at specified facilities from 0.5 psia to 0.1 psia, and also requires domes to be installed on certain external floating roof tanks at these facilities.

3.0 Analysis / Emission Reduction Estimates

3.1 Reduction of Vapor Pressure Applicability Criteria

Currently, Regulation 8, Rule 5 does not address tanks which store liquids with a true vapor pressure less than or equal to 0.5 psia. As noted above, only SCAQMD Rule 1178, addresses such tanks, and only at petroleum facilities. If the control requirements of Regulation 8, Rule 5 were applied to tanks containing liquids with vapor pressures of 0.5 psia and lower, their emissions would be reduced. However, tank emissions are inversely related to the vapor pressure of the liquid contents, and tanks storing low vapor pressure liquids will have lower emissions than tanks storing higher vapor pressure liquids. Therefore, cost-effectiveness is the main obstacle to implementation of a reduced vapor pressure applicability criterion. Another obstacle is the lack of a generally-applicable and cost-effective analytical method to measure organic vapor pressure below 0.5 psia.

3.1.1 Available Emission Reductions and Cost Effectiveness

Because the SCAQMD has implemented an applicability criterion of 0.1 psia in their Rule 1178, this vapor pressure will be the basis for the emission reduction estimate in this study. As noted in Section II, the District database includes about 900 tank sources that are exempt from permit requirements on the basis of liquid vapor pressure.

Regulation 8-5-301 specifies the basic design requirements for tanks. Low vapor pressure tanks (>0.5 to ≤1.5 psia) with a capacity of less than 39,326 gallons may comply with 8-5-301 with no more than a submerged fill pipe. Therefore, applying Regulation 8, Rule 5 to tanks of this size with a vapor pressure between 0.1 psia and 0.5 psia is not expected to result in significant emission reductions. Tanks with a capacity of 39,326 gallons or more are required to use an internal or external floating roof or an emission control system. Therefore, emission reductions from lowering the vapor pressure criterion would be expected to be realized at tanks with a capacity of 39,326 gallons or more, which store liquids with a vapor pressure between 0.1 and 0.5 psia, and which provide a lower control efficiency than an external floating roof tank (i.e. an uncontrolled fixed roof). A query of the District databank (See Section 4.2) indicates that there are 154 tanks which meet this criterion. The sum of the most recent District annual emission estimates for these 154 tanks was 161 tons of organics.

Chapter 7.1.2.1 of U.S. EPA’s AP-42 document (Reference 4) estimates that emissions from a fixed roof tank may be reduced from 60 to 99 percent by the use of an internal floating roof. On this basis, the expected emission reduction from conversion of these 154 tanks from uncontrolled fixed roofs to floating roofs is between 97 ton/yr and 159 ton/yr, or between 0.6 and 1.0 ton per year per tank. It should be noted that new floating roofs subject to rim seal and deck fitting standards in Regulation 8, Rule 5 would be expected to achieve an emission reduction exceeding 90%. Emission control systems require a minimum abatement efficiency of 95%.

There are probably additional tanks in this category that are not included in the District database, and therefore the total potential emission reduction may be higher than estimated. However, even if this were the case, the emission reduction per tank would be expected to remain no higher than 1 ton per tank per year, since the sample of 154 tanks is fairly large and probably representative of the entire population of tanks in this category.

Realization of this potential emission reduction would require either conversion of a fixed roof tank to an IFRT or the addition of an emission control system such as vapor recovery.

In the Final Staff Report for Proposed Rule 1178 (Reference 5, page 23), the SCAQMD obtained manufacturer estimates of costs to retrofit fixed roof tanks with internal floating roofs. The costs were based on tank diameter, but did not include the costs of degassing and cleaning the tank, or production costs associated with temporary loss of tank capacity. Using these costs, retrofit of the 154 tanks in the District would cost a total of $12,874,000, for a cost effectiveness between $34,000 per ton and $20,500 per ton (See Section 4.2). These estimates assume that no tank replacements are required because a tank is unfit for conversion.

The costs for abatement with an emission control system are highly variable. At a facility with an existing vapor recovery system and available system capacity, some tanks could be accommodated at a minimal cost. If no vapor recovery system were available or if the system had no excess capacity, costs could be significantly higher. For this reason, the IFRT conversion cost is the only cost effectiveness basis provided for this study item.

3.1.2 Vapor Pressure Measurement Methods

The District test method for determining true vapor pressure of organic liquids in storage tanks (Reference 6) is not valid at vapor pressures less than or equal to 0.5 psia. There is no method of measuring true vapor pressures in this pressure range which could be applied to any organic liquid. Some specialized methods exist, such as ASTM D2878-95(2000)e1, which is applicable to lubricating oils at elevated temperatures.

SCAQMD Rule 1178 includes standards for tanks storing liquids with true vapor pressures greater than 0.1 psia. In this rule, no attempt is made to directly quantify vapor pressures between 0.1 and 0.5 psia. Instead, the rule uses two different surrogate test methods to determine if the 0.1 psia applicability criterion is exceeded. For tanks storing liquids at ambient temperature, ASTM Method D93 (Reference 7) is used to determine the flash point of the contents, with those materials with a flash point less than 100 degrees F assumed to also have a vapor pressure exceeding 0.1 psia. Flash point is the lowest temperature at which a liquid or liquid mixture can form an ignitable mixture in air. For tanks storing liquids above ambient temperature, ASTM Method D86 (Reference 8) is used to determine the volume percent of a sample of stored liquid that evaporates at a reference temperature, with those materials undergoing more than 10% evaporation assumed to also have a vapor pressure exceeding 0.1 psia. Because Method D86 treats water as an organic material, and because crude oils may contain significant amounts of water, crude oils have been exempted from the requirements of Rule 1178 which are triggered by vapor pressure (Reference 5, Public Comment 8-3).

Since Rule 1178 was adopted in December 2001, the surrogate ASTM methods have been successfully used to implement the requirements of this rule.

3.2 Conversion of External Floating Roof Tanks to Internal Floating Roof Tanks

This study item requires quantification of emission reductions available by requiring conversion of external floating roof tanks (EFRTs) to internal floating roof tanks (IFRTs).

3.2.1 Floating Roof Technology

An EFRT is an open-topped cylindrical steel shell with a roof that floats on the stored liquid. By rising and falling with the level of the liquid in the tank, a floating roof prevents evaporation of the stored liquid and the formation of large volumes of organic vapor, which would be expelled when the liquid level rises. The floating roof consists of a deck, deck fittings (penetrations through the deck which serve various functions) and a rim seal system. The openings through which deck fittings penetrate the deck are typically sealed with gaskets, flexible boots, tape or other means. The rim seal system is attached to the outer circumference of the deck and is designed to close the gap between the deck and the inner tank shell. Although EFRT decks are equipped with a drain to prevent water from accumulating on the roof, the EFRT deck is still designed to operate with some amount of deck loading and is typically formed from welded steel plates.

An IFRT is a floating roof tank that has a fixed roof covering the floating roof. The fixed roof is not designed to be a vapor barrier. In fact, IFRT fixed roofs are commonly designed with “circulation vents” that allow ventilation of the vapor space above the floating roof in order to prevent an explosive accumulation of organic vapors in that space. IFRTs were originally designed to be used in areas where heavy rain or snow could overload the deck or otherwise affect its operation, since the fixed roof covered the floating deck. Later, it was recognized that IFRTs had lower emission levels than EFRTs in the same service because the fixed roof blocked wind that would otherwise contribute to emissions from the rim seal system and from the opening around deck fittings. Because their decks are not subjected to loading from snow or rain, IFRTs are generally equipped with lighter decks than EFRTs. The deck of an IFRT has no air quality benefits compared to an EFRT deck – both types of tanks have similar deck fittings and can use the same rim seal technology. On the other hand, because an IFRT deck may be lighter than an EFRT deck, it is sometimes made of non-welded panels, and ”deck-seam” losses are an additional emission path on these IFRTs which do not occur on welded EFRT decks.

A domed EFRT is a tank originally built as an EFRT that has been retrofitted with a dome. The benefits are the same as for an IFRT, including protection of the deck from the environement and reduced emissions from rim seal systems and deck fitting openings. The domes are typically aluminum, self-supported structures.

True conversion of an EFRT to an IFRT would require replacement of the original heavy deck with a lighter deck, and addition of a fixed roof. However, because the IFRT deck does not represent an air quality improvement compared to an EFRT deck, a true conversion is not contemplated. Instead, this Study Item will examine emission reductions from retrofitting EFRTs with domes. This control measure was implemented in SCAQMD Rule 1178 for EFRTs at petroleum facilities that contain liquids with a true vapor pressure of 3.0 psia or more.

3.2.2 EFRT Emissions Compared to IFRT Emissions

As noted in Section 2.3, the District database includes 310 external floating roof tanks. Total emissions from these tanks were 809 tons of organics in the most recent permit renewal period (See Section 4.3). As discussed in Section 2.4, these calculated emissions are probably an underestimate because the District database does not include deck fitting data for these tanks, and therefore neglects emissions from deck fitting losses.

The floating roof tank emission correlations in U.S. EPA’s AP-42 (Reference 4, Section 7.1.3.2) can model the effect of wind on rim seal emissions and deck fitting emissions, and thus the effect of a dome. However, because the District database does not include deck fitting types and counts for specific tanks and does not contain current seal configuration data, it is not possible to use these correlations to directly calculate the difference in emissions from EFRTs in the District if they were retrofitted with domes. However, an examination of the emission correlations with regard to rim seals and deck fittings (Reference 4, Section 7.1.3.2, Equations 2-2 and 2-5) shows that the wind-induced component of the total rim seal and deck fitting emissions could be more than 50% of the total emissions. The Final Staff Report for SCAQMD Rule 1178 (Reference 5, page 11) calculated an average rim seal emission reduction of almost 80% and a deck fitting emission reduction of almost 50% for a group of tanks storing a variety of organic liquids, using AP-42 correlations.

Because of the uncertainty in the available emission reduction from dome retrofits, no attempt will be made to establish cost effectiveness for a dome retrofit requirement for EFRTs.

3.3 More Stringent Tank Cleaning Standards

This study item requires quantification of emission reductions available by imposing more stringent tank cleaning standards. Tanks are cleaned when the accumulation of sludge inside the tank causes an unacceptable loss of tank capacity, or when the sludge affects product quality. The frequency of tank cleaning depends on the material being stored, and the material throughput through the tank. However, most tanks are cleaned infrequently and most often once every 5 to 10 years. Tanks are also cleaned prior to decommissioning.

3.3.1 Tank Cleaning Procedures

Tank cleaning involves first draining the tank as far as possible through the tank drain, then removing remaining product with a vacuum truck. After as much liquid as possible has been removed, the tank is degassed to lower the concentration of organic vapors in the tank, although the concentration is never reduced to zero. At this point, the tank interior may be accessed through manways and hatches. Sludge is removed and the tank interior is cleaned, either with pressurized steam or by flushing with a liquid.

For fixed roof tanks, emissions may occur when liquid is removed from the tank by vacuum if the liquid is allowed to displace organic vapors from the vacuum truck, and emissions also occur when the tank is degassed if the removed organic vapor is not completely collected. Emissions occur as well when the tank interior is accessed, as residual organic vapors are vented to the atmosphere. Finally, sludge removed from tanks may be a source of fugitive organic emissions.

In general, the emissions produced by cleaning a specific fixed roof tank are determined by the amount of residual liquid remaining in the tank after the tank is drained and also by the capacity of the tank, which determines the volume of residual organic vapors which must be degassed and also the volume of residual vapors which are vented to the atmosphere after degassing is performed. For floating roof tanks, because the level of the roof drops as the tank is drained, the volume of residual vapor is less than that for a fixed roof tank of the same capacity.

3.3.2 Current Requirements and Potential Improvements

Tank degassing is regulated by Regulation 8-5-328, which requires tanks larger than 19,803 gallons to be degassed prior to opening them to the atmosphere, and also prohibits uncontrolled degassing of any tank subject to the rule when the District has predicted an exceedance of a state or federal ozone standard for the following day. Degassing may be performed by liquid balancing (withdrawing organic liquid while simultaneously adding low vapor pressure liquid until the resulting liquid has a vapor pressure less than 0.5 psia), or by venting the tank to a control device with a minimum abatement efficiency of 90% until the residual organic concentration is less than 10,000 ppm. This residual amount of VOCs may be released to the atmosphere uncontrolled. Regulation 8-5-502 requires an annual source test for control devices to verify the required abatement efficiency. The handling of sludge removed from tanks is not currently regulated. Sludge contains VOCs that may be released after the sludge is removed from the tank, and sludge is a potential source of nuisance odors.

"More stringent standards" may include any the following:

• lowering the tank capacity (currently 19,803 gallons) at which the current standards are triggered; VCAPCD Rule 74-27 applies degassing requirements to gasoline tanks with a capacity greater than 5,000 gallons

• lowering the residual vapor concentration (currently 10,000 ppm) standard; SJVUAPCD Rule 4623 uses a 5,000 ppmv standard, although this is only one of several compliance options

• increasing the required minimum abatement efficiency for control devices used to degas tanks (currently 90%); VCAPCD Rules 74-26 and 74-27 require a minimum efficiency of 95% by weight

• replacing the annual source test requirement; VCAPCD Rules 74-26 and 74-27 require real-time monitoring of control device abatement efficiency

• regulating the handling of sludge removed from tanks: SJVUAPCD Rule 4623 requires that sludge removed from tanks storing liquids with a vapor pressure greater than or equal to 1.5 psia be abated, and also limits the use of steam cleaning of tank interiors (which results in higher emissions than other cleaning methods)

3.3.3 Potential Emission Reductions

3.3.3.1 Of the potential improvements identified in Section 3.3.2, increasing the required control device efficiency is the most easily implemented since many control systems probably already provide an efficiency of 95% or more. For this same reason significant emission reductions are unlikely for this change. Quantification of the potential emission reduction is difficult because only very limited data is available on actual efficiency of control systems in use.

3.3.3.2 Lowering the allowed residual vapor concentration from 10,000 ppm would result in emission reductions because the tank vapor space is vented to the atmosphere once the allowed concentration is reached. Lowering the residual concentration would not affect any tanks not already subject to this requirement, although all tanks required to control degassing would require longer degassing times, with associated increased costs for degassing contractors, as well as indirect costs associated with loss of tank availability.

Assuming a 10,000 ppm residual concentration in each tank with a capacity greater than 19,803 gallons, and assuming that each tank is degassed every 10 years, fixed roof tanks would produce an average total emission of about 4 tons per year (See Section 4.4). Floating roof tanks, assuming that only 10% of the total tank capacity requires degassing after the roof has reached its lowest level, would produce an average total emission of less than 1 ton per year. Because this potential reduction is not large, no attempt will be made to quantify cost-effectiveness for achieving a lower residual organic concentration.

3.3.3.3 Replacing the annual source test with real-time monitoring would probably involve negligible cost since monitoring equipment is already necessary under the existing requirements to verify that degassing has lowered the residual organic concentration to the required level of 10,000 ppm. Further, the cost of an annual source test would be eliminated for each emission control system. Although this improved monitoring method may not result in significant emission reductions, it is an obvious improvement.

3.3.3.4 Regulating the handling of sludge would result in an unknown emission reduction since emissions depend on the amount of sludge produced, the residual VOC concentration and the handling procedures used. Even if these variables were known for each tank, calculation of an actual emission rate would be difficult and imprecise. However, simple and inexpensive control measures like gas-tight containers for sludge could be implemented at a minimal cost.

3.4 Floating Roof Tanks Compared To Vapor Recovery

This study item requires determination of air quality benefits from the use of vapor recovery abatement instead of the use of floating roofs on tanks, considering Bay Area data and experience. Study Measure FS-10 notes that U.S. EPA guidance considers floating roofs to provide emission control equivalent to a vapor recovery system. No California air district prohibits or limits the use of floating roof tanks in favor of abated fixed roof tanks.

Vapor recovery refers to any process that collects organic vapors produced by tanks and then either destroys or recovers the organic product. Vapor recovery may be designed to collect emissions continuously, or only during processes which result in especially high emissions, such as filling of floating roof tanks up to the point where the rising liquid comes into contact with the tank roof. The most common example of vapor recovery in the Bay Area is the venting of fixed roof tanks at petroleum refineries to a collection system, with the collected gas (after treatment and blending) used as fuel at refinery combustion sources. Only fixed roof tanks are compatible with continuous vapor recovery. Because floating roof tanks produce emissions around the entire periphery of the floating roof at the rim seal, as well as from individual deck fittings, it is not practical to attempt to collect these emissions with a vapor recovery system. Fixed roof tanks, on the other hand, may be controlled by venting the pressure control devices on the tank to the vapor recovery system.

Vapor recovery is commonly used at refineries because these facilities can use the recovered vapors as fuel, thereby reducing purchased fuel costs. Because they may use the recovered vapors directly, refineries do not have to install costly recovery systems such as condensers. The vapor recovery system is already in place because refineries need to be able to handle waste gases from various processes, although additional gas compressor capacity may be required to handle vapors from tanks. Vapor recovery is also found at petroleum bulk terminals where large numbers of large tanks storing a limited number of products make vapor recovery cost-effective even where no fuel gas system exists.

The District database includes 107 fixed roof tanks at 10 facilities which use vapor recovery to comply with Regulation 8, Rule 5 (See Section 4.5). One refinery accounts for 58 of these tanks, which is over 50% of the total. Thus, only about 4% of fixed roof tanks in the District are abated by vapor recovery, and there are almost 5 times as many floating roof tanks as there are abated fixed roof tanks. Floating roof tanks are overwhelming preferred over abated fixed roof tanks because their design is largely passive, requiring relatively few resources to operate continuously and automatically. Vapor recovery systems, on the other hand, can be complex and are more susceptible to operator error or mechanical failure. The major components of a floating roof tank often last for decades, while compressors and other vapor recovery system components require frequent maintenance and are shorter-lived.

Vapor recovery systems are required to continuously achieve an abatement efficiency of at least 95% by Regulation 8-5-306. This efficiency could approach 100% for a vapor recovery system vented to a fuel gas system. However, where no fuel gas system is available, it is difficult to maintain this high level of abatement on a continuous basis. As discussed in Section 3.1.1, U.S. EPA estimates that a floating roof reduces emissions from those of an uncontrolled fixed roof tank from 60 to 99%, although the rim seal and deck fitting standards in Regulation 8, Rule 5 probably result in an emission reduction from a floating roof exceeding 90%.

As discussed in Section 3.1.1, the costs of implementing vapor recovery systems are highly variable, depending on the existing infrastructure at a particular facility. Also, floating roof tanks have a large range of emission levels, depending on tank size, material throughput and material vapor pressure.

3.5 Maintenance Program Provision

The regulated community has consistently requested that a maintenance program provision be added to Regulation 8, Rule 5. Such a provision would encourage more frequent inspections of floating roof tanks by providing a limited amount of time to repair minor non-compliant conditions discovered by the tank operator. Regulation 8, Rule 5 currently does not include such a provision, and all non-compliant conditions, including minor conditions discovered and promptly corrected by the tank operator, are subject to enforcement action. A similar provision, allowing up to 7 days for repair of non-compliant leaks discovered by the operator, is included in Regulation 8, Rule 18 (“Equipment Leaks”).

The potential emission reduction available from implementing such a maintenance provision is unquantifiable. However, cost effectiveness is not an issue because this maintenance provision would simply be an additional compliance option.

4.0 Supporting Data

Data on tank populations and associated emissions was taken from District records. The District operates two database systems. Although both systems contain the same raw data, each have different tools for data retrieval. Most data were retrieved from the IRIS database using the Hummingbird BI-query tool. Other data were taken from the Databank database using the HP-3000 command interface. Each set of retrieved data is discussed below.

4.1 Tank population records in Section 2.3

A data request (December 30, 2003) identified all sources classified as tanks, the facilities where they are located and a count of the number of individual tanks in each sourcetype. Only "active" sources were listed, not records for tanks that have been removed from service. These results allowed the derivation of the tank counts in Section 2.3.

A second data request (January 7, 2004) identified all tanks classified as exempt from permits. Only "active" sources were listed, not records for tanks that have been removed from service. By qualifying the volume of exempt tanks, the number of exempt tanks of any particular size can be determined. These results allowed the derivation of the exempt tank count in Section 2.3.

4.2 Unabated fixed roof tank population in Section 3.1

A data request (January 7, 2004) identified all fixed roof tanks with a volume of 39,326 gallons or more and that contain liquids with a true vapor pressure (TVP) between 0.1 and 0.5 psia. For each tank meeting this criteria, the facility at which the tank is located and the tank diameter were also retrieved. Only "active" sources were listed, not records for tanks that have been removed from service.

The emissions for each identified tank were extracted from the database for the most recent inventory year (2003) and summed to provide the total emissions from this category of tank. Abated tanks were identified and excluded from the tank count and their emissions were excluded from the emission total.

Floating roof retrofit costs were taken from Table 6-4 of Reference 5, with the tank diameter rounded to the closest value for which a cost was provided. The annualized cost was assumed to be equal to 0.253 of the total installed cost, in accordance with the default procedure in Section 3.3 of the District BACT/TBACT Workbook.

4.3 EFRT emissions in Section 3.2.2

A data request (January 2, 2004) identified all EFRTs. The emissions for each identified tank were extracted from the database for the most recent inventory year (2003) and summed to provide the total emissions from this category of tank.

4.4 Degassing emissions in Section 3.3.3.2

A data request (January 12, 2004) retrieved all records for tanks with a capacity greater than 19,803 gallons and summed the capacities for fixed roof tanks and floating roof tanks of this size. For fixed roof tanks, the total volume was assumed to be vented every 10 years; for floating roof tanks, 10% of the total volume was assumed to be vented, also every 10 years. The vented gas was assumed to have a residual concentration of 10,000 ppmv, expressed as methane, as specified in Regulation 8-5-328.1.2. This gas was assumed to be ideal and at standard conditions. Using the ideal gas law, the molar quantity of emissions was calculated for both groups of tanks, and using the molecular weight of methane, this was converted to a mass emission rate.

Fixed roof tanks:

Fixed roof tanks in this category had a total volume of 1,302,188,000 gallons. Ideal gas at standard conditions has a volume of 359 ft^3 per mole of gas. Then, assuming this total volume was emitted to the atmosphere over a 10 year period, with a residual organic concentration of 10,000 ppmv, the annual molar emissions would be:

$$(10{,}000/1\text{ million})(1{,}302{,}188{,}000\text{ gallons}/10\text{ yr})(\text{ft}^3/7.48\text{ gallons}) / (359\text{ ft}^3/\text{lbmole})$$
$$= 485\text{ lbmole/yr}$$

For methane:

$$(485\text{ lbmole/yr})(16\text{ lb/lbmole}) = 7{,}760\text{ lb/yr}$$

Floating roof tanks:

EFRTs in this category had a total volume of 1,623,658,000 gallons, and IFRT's in this category had a total volume of 300,587,000 gallons, for a total volume of 1,924,245,000 gallons. Ideal gas at standard conditions has a volume of 359 ft^3 per mole of gas. Then, assuming 10% of the total capacity was emitted to the atmosphere over a 10 year period, with a residual organic concentration of 10,000 ppmv, the annual molar emissions would be:

$$(10{,}000/1\text{ million})(1{,}924{,}245{,}000\text{ gallons}/10\text{ yr})(0.1)(\text{ft}^3/7.48\text{ gallons}) / (359\text{ ft}^3/\text{lbmole})$$
$$= 72\text{ lbmole/yr}$$

For methane:

$$(72\text{ lbmole/yr})(16\text{ lb/lbmole}) = 1{,}152\text{ lb/yr}$$

4.5 Fixed roof tanks with vapor recovery in Section 3.4

A data request (January 8, 2004) identified all fixed roof tanks abated by devices classified as vapor recovery devices. Each identified tank and abatement device were reviewed and some abatement devices were found to have been incorrectly classified as vapor recovery devices and were therefore excluded. To ensure that no tanks were missed because of abatement device misclassification, the Title V permits for the 5 Bay Area refineries were also reviewed. These permits list all facility abatement devices, abated sources and the regulatory requirement that requires the use of the abatement device.

5.0 Recommendations

1) Lowering vapor pressure applicability criterion of Regulation 8, Rule 5. Based on data from the District database, 154 fixed roof tanks would be required to be replaced with floating roof tanks, retrofitted with floating roofs or provided with an emission control system if the current vapor pressure applicability criterion in Regulation 8, Rule 5 were lowered from 0.5 psia to 0.1 psia. The potential emission reduction is approximately between 100 ton/yr and 160 ton/yr, with a cost effectiveness between $20,500 per ton and $34,000 per ton.

Rule 1178 ("Further Reductions of VOC Emissions from Storage Tanks at Petroleum Facilities") at the South Coast AQMD recently implemented requirements for tanks in this pressure range. Based on the implementation of this rule, it appears that adequate surrogate analytic methods are available to measure low vapor pressure materials, with the notable exception of crude oils. This methodology would allow enforcement of standards for materials with vapor pressures as low as 0.1 psia.

Because the cost of implementation for this measure is quite high, other control measures should take precedence in rulemaking.

2) Retrofitting EFRTs with domes. A lack of readily available data on specific rim seal designs and deck fitting designs and counts at tanks in the District makes it difficult to quantify the potential emission reduction from this measure. However, U.S. EPA's emission correlations for floating roof tanks indicate that retrofitting EFRT's with domes can significantly reduce overall emissions from these tanks. The 310 EFRTs currently in service are estimated to produce over 800 tons per year of organic emissions. Dome retrofits could reduce this emission level by 50% or more, as discussed in Section 3.2.2. Because of the significant potential emission reductions, further research should be undertaken to more precisely establish the available emission reduction and cost effectiveness of this measure.

3) Imposing more stringent tank cleaning standards. Although the emission reductions available through this control measure do not appear to be large, the District could undertake rulemaking to require a minimum abatement efficiency of 95% by weight for control of degassing emissions, and improve the monitoring of degassing abatement by requiring real-time monitoring of degassing operations, instead of the currently required annual source test. Rulemaking could also be undertaken to impose sludge handling requirements that would minimize fugitive emissions and odors from tank sludge.

4) Benefits of vapor recovery compared to floating roofs. Where a facility can make use of recovered tank vapors for fuel, as at several refineries, vapor recovery abatement of fixed roof tanks offers the highest possible abatement of tank emissions, approaching

100%. For other vapor recovery technologies, it is difficult to continuously provide the same level of abatement as a floating roof, which is typically over 90%. Floating roof tanks are almost 5 times as common as fixed roof tanks abated by vapor recovery in the Bay Area. Because of the reliability of floating roofs, which are a passive abatement technology, it is not clear that vapor recovery could offer a greater overall emission reduction, considering the greater likelihood of breakdowns with a vapor recovery system. Also, vapor recovery systems have a large variability in cost from facility to facility, depending on the existing facility infrastructure. This variability makes cost effectiveness calculations difficult and suggests that implementation costs would vary widely for different facilities. Also, floating roof tanks have a large range of emission levels, depending on tank size, material throughput and material vapor pressure. Therefore, rulemaking could be undertaken to determine which classes of floating roof tanks, if any, should be prohibited in favor of continuous vapor recovery with abated fixed roof tanks. Rulemaking could also determine whether non-continuous vapor recovery, as during the initial filling phase of an empty floating roof tank, should be required.

5) Maintenance program provision. The District should undertake rulemaking to amend Regulation 8, Rule 5 to include a maintenance program provision. This provision would encourage more frequent inspections of floating roof tanks by providing a limited amount of time to repair minor non-compliant conditions discovered by the tank operator.

6.0 Glossary

BAAQMD: Bay Area Air Quality Management District

CARB: California Air Resources Board

EFRT: external floating roof tank

IFRT: internal floating roof tank

POC: precursor organic compound

psia: pounds per square inch, absolute (a measurement of pressure)

SCAQMD: South Coast Air Quality Management District

U.S. EPA: The United States Environmental Protection Agency

VOC: volatile organic compound

7.0 References

1. "Revised San Francisco Bay Area Ozone Attainment Plant for the 1-Hour National Ozone Standard" ("2001 Ozone Attainment Plan"), adopted October 21, 2001; Bay Area Air Quality Management District, Association of Bay Area Governments, Metropolitan Transportation Commission

2. BAAQMD Regulation 8, Rule 5, "Storage of Organic Liquids", adopted November 27, 2002.

3. "Evaporative Loss From External Floating-Roof Tanks", Chicago Bridge & Iron Technical Services Company, CBI Technical Publication Number CBT-5536, April 1989.

4. "Compilation of Air Pollutant Emission Factors" (AP-42), 5th Edition, January 1995; United States Environmental Protection Agency

5. Final Staff Report, Proposed Rule 1178 ("Further Reductions of VOC Emissions From Storage of Organic Emissions at Petroleum Facilities"), South Coast Air Quality Management District, December 11, 2001

6. BAAQMD Laboratory Method 18, "Determination of Vapor Pressure of Organic Liquids From Storage Tanks")

7. ASTM Method D93, "Standard Test Methods for Flash-Point by Pensky-Martens Closed Cup Tester"

8. ASTM Method D86, "Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure"